The World Needs Wicked Scientists

How can we train the next generation of researchers to tackle society's most vexing problems?

Mark Moritz and Nicholas C. Kawa

Many problems facing humanity are so daunting they seem impossible to solve. Among these problems are global climate change, food insecurity, growing socio-economic inequality, systemic racism, and emerging infectious diseases. Yet it is precisely these problems—identified by a growing number of scholars as "wicked problems"—that society most urgently needs to address. How, then, can our expanding scientific understanding of wicked problems help us to better approach them? And what specific skills, attitudes, and knowledge do scientists need to effectively tackle them?

To begin, we should establish that wicked problems have two fundamental properties. First, they are complex, with many interdependencies. Second, the parties involved typically have different values, interests, and conceptions of the problem, as well as conflicting ideas about how best to work toward a resolution. Thus, because wicked problems are complex *and* political—or shaped by differential power relations and interests among actors—it is virtually impossible to "solve" them in any sustained manner. Wicked problems, by their very nature, defy simple resolution.

The qualities of wicked problems present distinctive challenges for researchers. The standard scientific approach is to conceptualize problems as having straightforward technical solutions, such as developing crop varieties that can better withstand extended periods of drought or creating reusable rocket ships for commercial space travel. However, when we ignore the complexity and political dimensions of such problems, we can face serious consequences. The Space Shuttle *Columbia* disaster, for example, was not simply the result of technical malfunction; it also stemmed from underlying organizational and cultural issues within NASA, including its hierarchical organization, the challenges of public–private partnerships, and a culture that encouraged engineers and managers to ignore the possibility of unusual circumstances and drastically underestimate the potential for catastrophe. In other words, the problems confronted by rocket scientists are not narrowly limited to the domains of science and engineering, but are also shaped by the broader dynamics of the social systems in which they are conceived.

A world of wicked problems calls for a more adaptive, playful, even slightly mischievous way of approaching science.

Though much has been written about the challenges of wicked problems and the need to address them, these discussions have not prompted the development of academic or other training programs that train scientists to effectively tackle wicked problems. As we have argued elsewhere, when researchers are trained to work in inclusive, transdisciplinary teams that consider both the complexities *and* politics of wicked problems, this can lead to more resilient, sustainable, and equitable outcomes. Even if we concede that such problems cannot be permanently solved, we can still work more effectively to minimize their harms.

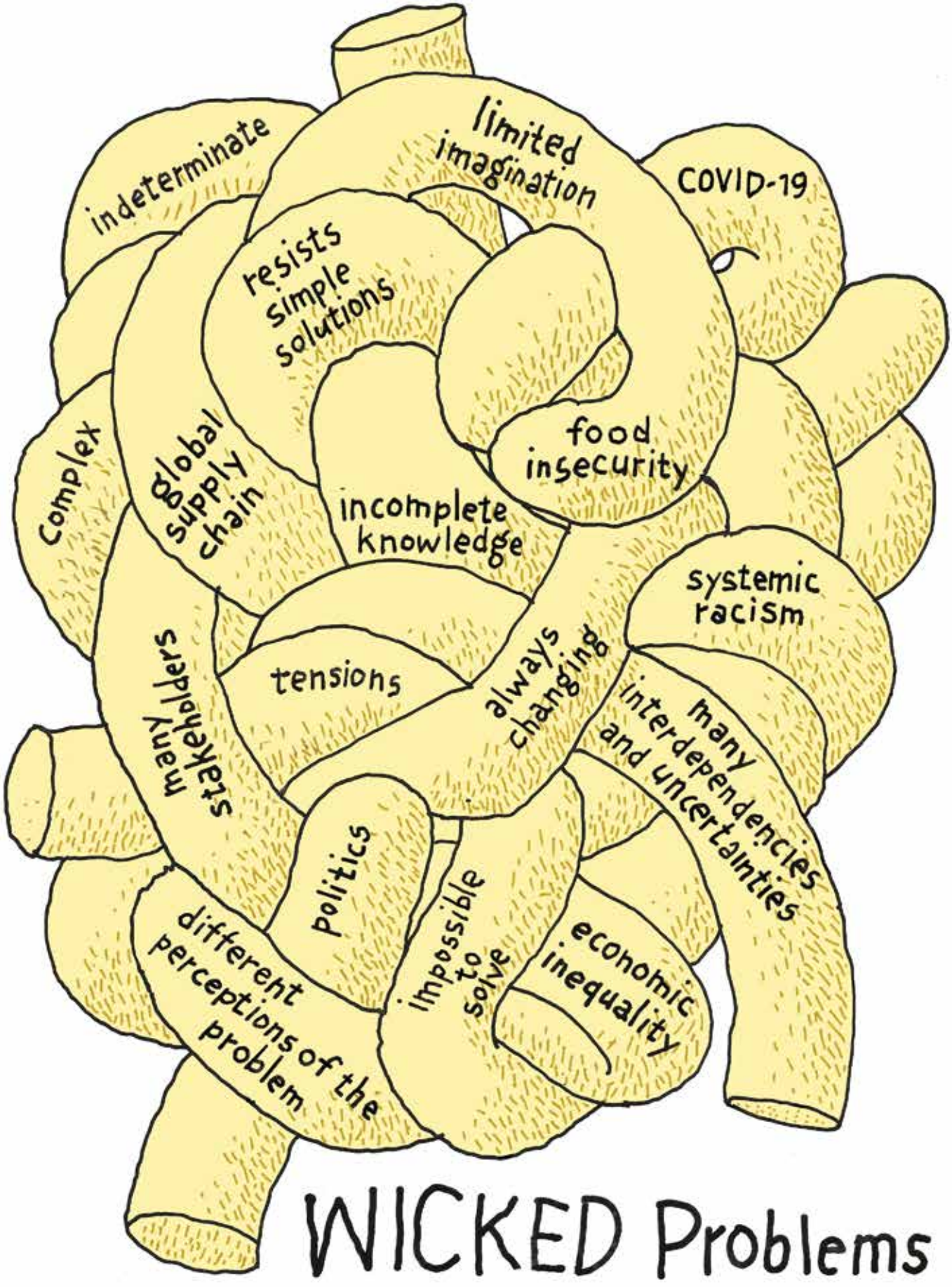
Wicked problems like COVID-19, global supply chain disruptions, economic inequality, and food insecurity are characterized by messy and complicated features that make them difficult or impossible to untangle. Transdisciplinary training programs can create a generation of wicked scientists armed with the specific skills, attitudes, and knowledge to effectively tackle them.

QUICK TAKE

The term *wicked problems* has been used to describe a wide range of social and cultural issues that seem difficult or even impossible to solve.

There is an urgent need for programs that bring together transdisciplinary teams specifically trained to consider both the complexity and the political nature of wicked problems.

Those trained as wicked scientists will be better positioned and prepared to intervene on such grand challenges in ways that can yield better, more equitable outcomes.


indeterminate
limited imagination
COVID-19
resists simple solutions
Complex
global supply chain
food insecurity
incomplete knowledge
systemic racism
tensions
always changing
many stakeholders
many interdependencies and uncertainties
politics
impossible to solve
economic inequality
different perceptions of the problem
WICKED Problems

Tom Dunne

Irwin/Kossoff, Transition Design Institute, Carnegie Mellon University; adaptation by Tom Dunne

Horst Rittel, a German design theorist, and Melvin Webber, an American city and regional planner, are credited with developing the concept of wicked problems. In their landmark 1973 paper "Dilemmas in a General Theory of Planning," they identified several characteristics of wicked problems, which are depicted here. The text in the bubbles is based on the synthesis of these characteristics by Terry Irwin and Gideon Kossoff, faculty at Carnegie Mellon University.

Not Just a Catchy Term

In 1973, Berkeley professors Horst Rittel and Melvin Webber coined the phrase "wicked problems" to describe social or cultural issues that are difficult or even impossible to solve. Given the seemingly futile nature of wicked problems, it might seem that developing a program that trains graduate students to combat them would be equally impossible. However, we maintain that such programs are both possible and necessary. At Ohio State, we and our colleagues have been developing such a program by systematically translating Rittel and Webber's concept of wicked problems into a novel conceptual framework of wicked science and "wicked scientists."

Our efforts began six years ago in meetings of the Social-Ecological Systems working group in the Department of Anthropology at The Ohio State University. In our weekly gatherings, we discussed food security, the opioid epidemic, urban mobility, and climate change adaptation—quintessential wicked problems that resist simple, straightforward solutions. One afternoon while cycling home from work on the Olentangy River Trail, we asked ourselves how we might train graduate students to tackle such wicked problems. The two of us half-jokingly decided that the world's wicked problems required training a generation of wicked scientists. Suddenly, our conceptual pieces began to fall into place.

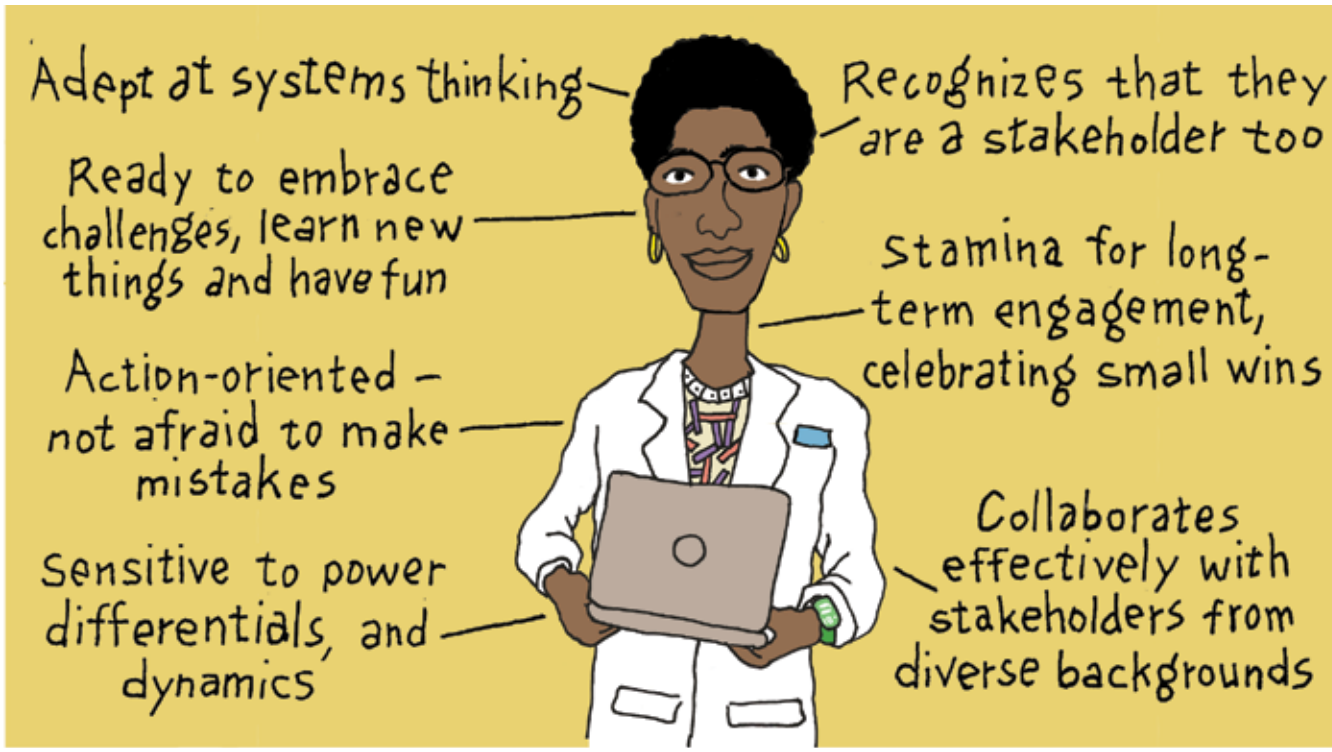
To be clear, wicked science is not just a catchy term—we use this neologism because it accurately and effectively describes our conceptual framework. Moreover, we use the term strategically to communicate an innovative vision for graduate training in the 21st century. The need for interdisciplinary research and training is already well appreciated, and scholars have begun developing many interdisciplinary programs to prepare students to work in a wide range of different fields. The Knowledge Integration program at the University of Waterloo, Canada, for example, offers a four-year program in which undergraduates develop skills in design thinking and integrating knowledge across traditional disciplinary boundaries. While there is admittedly much overlap between our concept of wicked science and other interdisciplinary programs, what sets ours apart is an emphasis on the complexity and politics of wicked problems. The term wicked scientist also helps us to communicate how and why the program matters.

Wicked science calls for a more adaptive, playful, even slightly mischievous way of approaching science. The word "wicked" can carry negative connotations suggesting evil or immoral behavior. A Google image search for "wicked scientist" yields cartoonish figures ranging from Dr. Frankenstein to a mad scientist in rain gear performing an experiment on a golden potato! However, "wicked" is also a superlative in popular slang—particularly in the Boston area—that can be used to indicate intensity ("This summer's been wicked hot!") as well as distinctive skill or ability. (Casey Affleck's character in *Good Will Hunting* quips in one of the movie's most memorable lines: "My boy's wicked smart.")

In many ways, the "wicked" in wicked problems is just as diverse and paradoxical as the challenges it characterizes. But this shape-shifting quality is something that wicked scientists can learn to appreciate and even embrace. When we say we need to train students to become wicked scientists, we are highlighting in a manner that is both serious and suggestive that the most challenging problems of our times require understanding and engagement with the inner contradictions and complexities of their constitutions.

Catalyzing Convergence

Our conceptual framework of wicked scientists aligns well with the concepts of transdisciplinary science and convergence. In the National Science Foundation's 10 Big Ideas, *convergence research* is described as "a means of solving vexing research problems, in particular, complex problems focusing on societal needs. It entails integrating knowledge, methods, and expertise



Tom Dunne

To be a truly wicked scientist, researchers must acquire a variety of skills and attitudes, shown here, that will equip them to deal with society's wicked problems. The team at The Ohio State University used the logic of backward design to derive these and other competencies from the concept of wicked problems. Willingness to have fun, for example, is critical for a long-term engagement with problems that defy easy solutions.

from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation." The training of wicked scientists is important because they will have the competencies to catalyze convergence in transdisciplinary teams working on a wide range of wicked problems.

Whereas interdisciplinary research involves researchers from different disciplines collaborating on a joint research problem working toward synthesis, *transdisciplinary research* integrates the conceptual contributions of numerous stakeholders in the study of a problem while working toward an engaged, socially responsible solution. Stakeholders are anyone with a stake in the problem, which could include individuals from communities, businesses, nongovernmental organizations, local, regional, and national governments, and researchers themselves. Thus, wicked science is transdisciplinary because it involves collaborations among researchers from different disciplines, as well as other stakeholders inside and outside academia, and it is convergence research because it involves vexing societal problems, that is, wicked problems.

Wicked science takes convergence research to the next level, as wicked scientists recognize that these societal problems are challenging not just because they are complex but also because they are political. Often, these problems impact diverse stakeholders who lack agreement on the root causes of the problem or the most viable solutions. The focus of scientific literature is often on the complexity of wicked problems, while stakeholder politics are often downplayed or ignored.

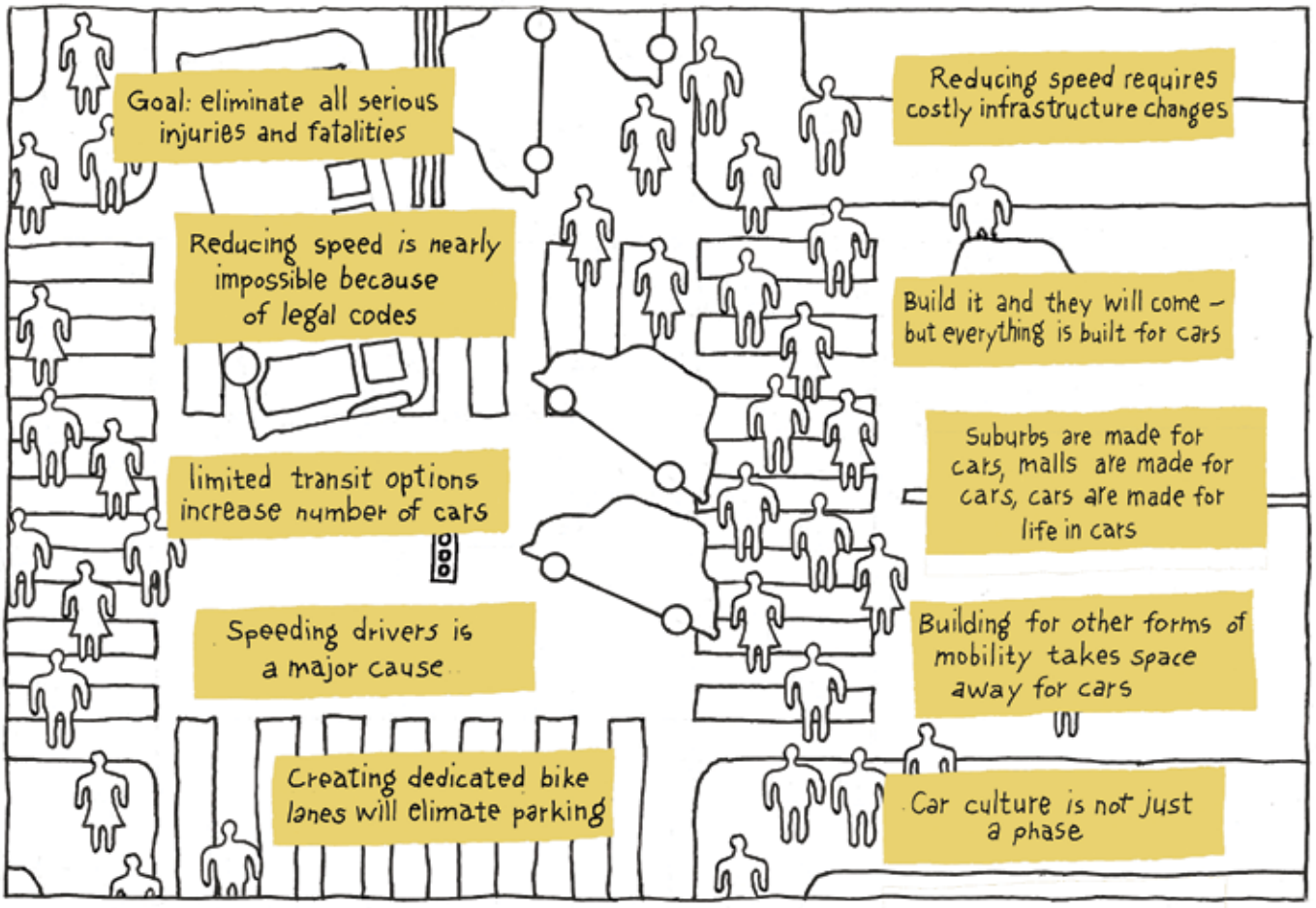
We argue that wicked scientists need training in systems approaches that emphasize the political dimensions of such problems. It is not enough to have the evidence and theoretical models. For science to move out into the world, researchers must address wicked problems in a way that acknowledges our dual roles as scientists and as stakeholders. We cannot stand on the sidelines or remain in the so-called ivory tower of academia. Of course, many scientists are already doing just that, but they are often the exception rather than the norm. However, outside of academia, professionals in a wide range of fields have developed wicked competencies on the job as they deal with wicked problems.

How to Train a Wicked Scientist

Once we latched onto this idea of wicked science, we worked backward to figure out the kinds of skills wicked scientists need to tackle wicked problems. We began by asking, given the properties of wicked problems, what competencies are required of wicked scientists to address them. Take, for example, the first three characteristics of wicked problems: they are complex without clear boundaries, there are no permanent solutions, and there are only better or worse solutions (or good-enough-for-now solutions). These characteristics demand that wicked scientists use a systems-thinking approach, be prepared for long-term engagement with wicked problems, and cultivate an attitude that good-enough-for-now solutions are worthy objectives.

Using this backward design approach, we derived 5 learning goals, 16 learning outcomes, and 58 proficiencies. The last proficiency is to "have fun," which is not just an Easter egg or hidden surprise, but rather a critical component of the long-term project of cultivating the grit, attitude, and courage necessary for tackling wicked problems.

Next, we used these learning outcomes and proficiencies to identify which existing university courses we could leverage, and what new courses we needed to develop to train wicked scientists. Then we organized these courses into a graduate interdisciplinary specialization aimed at graduate



Tom Dunne

The Vision Zero initiative of the City of Columbus is part of a global effort to reduce traffic fatalities and severe injuries to zero. A team of students from The Ohio State University assigned to help this initiative quickly learned that such wicked problems have no permanent solutions and that each solution can generate its own set of problems, as depicted here. Through the process, the students gained the mindset of a wicked scientist, which they can apply to similarly vexing problems in the future.

RossHelen editorial/Alamy Stock Photo

students across the university, from anthropology to veterinary medicine. The two existing courses we identified were "Interdisciplinary Team Science," which prepares students to collaborate effectively in diverse teams, and "Rapid Innovation for Public Impact," which trains students in problem solving using lean start-up theory and hands-on practice. In addition, we have developed a new "*Wicked Science*" course that will teach students to think of grand challenges as wicked problems, and a one-credit capstone course where students will synthesize what they have learned and demonstrate that they possess the competencies to tackle wicked problems in the career field of their choice.

Wickedness in Practice

The "Rapid Innovation for Public Impact" course is taught by our colleague Elizabeth Newton and U.S. Air Force Colonel (Ret.) Kevin Cullen at the Glenn College of Public Policy and is modeled after Stanford University's "Hacking for Defense (H4D)" course. While student teams in the original Stanford course worked on real-world problems offered by the Department of Defense, students in the Ohio State course wrestle with explicitly defined wicked problems provided by university, community, government, business, and other partners. Last semester, teams worked on a wide range of problems, including access to childcare for parenting students, identifying misinformation about sustainable energy, and recycling gas canisters.

One of the student teams was sponsored by Vision Zero Columbus, an Ohio-based group that is part of a global initiative to reduce traffic fatalities and severe injuries to zero. The initiative started in Sweden in the 1990s and has been adopted by multiple cities in the United States. In Columbus, traffic fatalities are a wicked problem. Like many American cities, Columbus's infrastructure has been designed for cars at the expense of other modes of transportation like transit, cycling, and walking. Since 2015, the problem has gotten much worse: Traffic fatalities on Columbus's streets have doubled.

The sponsor of the student team was Maria Cantrell, the coordinator of Vision Zero Columbus. Cantrell is an engineer for the City of Columbus, as well as a practicing wicked scientist who uses a systems-thinking approach to deal with the complexity and politics of reducing traffic fatalities. The team working with Cantrell consisted of three students from the colleges of engineering, public policy, and arts and sciences. These students interviewed more than 30 stakeholders from city departments like Public Service, regional transportation organizations like the Central Ohio Transit Authority (COTA), companies like Lyft, nonprofit organizations like Yay Bikes, and even neighborhood activists. In the process, they conducted research on best practices for traffic calming in other cities and analyzed the decision-making processes and criteria that shape infrastructure design in Columbus, particularly along Livingstone Avenue, which has one the highest number of injuries in the city.

The student team quickly learned that different stakeholders often did not agree on what the root cause of the problem is or how best to solve it. They also came to acknowledge that there are no permanent solutions, and that each solution generates its own set of problems. Through these activities, students developed "wicked competencies," like working with stakeholders from diverse backgrounds, communicating their work to different audiences in multiple modalities, cultivating the attitude and courage needed for tackling wicked problems, and recognizing the value of wrestling with wicked problems regardless of the immediate results.

In their final report, the students proposed both short- and long-term solutions to reduce traffic fatalities. The short-term solutions were more technical and focused on increasing the visibility of pedestrians and on reducing the speed of cars through improvements such as striping crosswalks and replacing intersections with roundabouts. Their long-term solutions were more structural and focused on integrating Vision Zero principles into all of the projects of Columbus's Department of Public Policy, and on expanding the Vision Zero team. It is noteworthy that the city was simultaneously working on similar structural changes, indicating that the students were quick learners and on the right track.

Through our work with this student team, we gleaned important lessons that can be applied to our wicked science program, which we plan to launch in the coming academic year. For example, we learned that both transdisciplinary science skills and the conceptualization of wicked problems are critical, suggesting that students may be even more successful once they have completed not only the "Rapid Innovation for Public Impact" course but also the other offerings in the wicked science program. In addition, we found that Cantrell, the student team sponsor, embodied all the wicked competencies we had identified, demonstrating that there are already wicked scientists in our midst who can serve as mentors for similar programs.

A New Science for a New Generation

While the science of the 20th century focused on the increasing specialization of disciplinary knowledge and training within academic institutions, the 21st century demands integration across disciplinary lines, as well as deeper engagement with the communities and collective problems that exist beyond the confines of the academy. Simply put, business-as-usual is no longer effective for tackling the most pressing problems of our time, whether it be urban sustainability, global climate change, systemic racism, or widening economic inequality.

Organizations like the National Science Foundation and the National Academies of Sciences, Engineering, and Medicine, as well as companies like Google, are looking for models that prepare students for convergence research. We and others across the nation are developing new models with that goal in mind. Wicked science offers an innovative approach that is grounded in best practices and can be readily adopted by faculty and programs at other universities.

For science to move out into theworld, researchers must address wicked problems in a way that acknowledges our dual roles as scientists and as stakeholders.

Wicked scientists might never solve any of the wicked problems they face. In fact, none of us likely will. But those trained as wicked scientists will be better positioned to intervene in such grand challenges in ways that can yield better, more equitable outcomes. A world of wicked problems calls for a more adaptive, playful, even slightly mischievous way of approaching science. If we can train a generation of students to take up the challenge of enacting a new transdisciplinary vision of science, well, that would be quite wicked indeed.

Bibliography

Kawa, N. C., et al. 2021. Training wicked scientists for a world of wicked problems. *Humanities and Social Sciences Communications* 8:189.

Rittel, H. W. J., and M. M. Webber. 1973. Dilemmas in a general theory of planning. *Policy Sciences* 4:155–169.

Mark Moritz is a professor of anthropology at The Ohio State University in Columbus, Ohio whose interdisciplinary research focuses on the wicked problem of sustainable management of common-pool resources in pastoral systems. Nicholas C. Kawa is an assistant professor of anthropology at The Ohio State University who studies the wicked problem of managing sewage sludge as a renewable resource for agricultural production and ecological restoration in the American Midwest. Email for Moritz: moritz.42@osu.edu